From identification to a chemical fingerprint for explosives in forensic research

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Cobra firework. Credit: Karlijn Bezemer

The police frequently encounter explosives in their forensic investigations related to criminal and terrorist activities. Chemical analysis of explosives can yield valuable tactical information for police and counter-terrorist units. Within the compass of her doctoral research, Karlijn Bezemer has developed a new generation of tools which can be used to not only identify signature properties of explosives and their raw materials but also to enable comparison of explosives. Bezemer, who works at the Netherlands Forensic Institute (NFI), is set to obtain her Ph.D. at the University of Amsterdam (UvA) on Wednesday, 2 September.

In traditional forensic casework, explosives experts focus on matters such as the chemical identification of an explosive. "Identifying the type of explosive material isn't the only important aspect, though," Bezemer explains. "Increasingly, the Public Prosecution Service is asking the NFI whether there might be a link between two crime scenes (e.g. different attacks on ATMs), or between material found at a crime scene and raw materials found at a suspect's home. The distinctive chemical profiles of explosives can be used to establish (or refute) commonalities in terms of source, thereby assisting with forensic investigations. If the police don't have a suspect yet, but tactical information can be derived from the explosive material, this could put them on a suspect's track."

Bezemer's research enables her to cross the boundary from forensic evidence into forensic intelligence. In the future, information obtained through explosives profiling and intelligence could even be used to prevent incidents with explosives from happening. Bezemer has focused her research on three main topics: organic explosives, fireworks, and the detection of firework traces.

Homemade explosives

The use of explosives is popular among terrorists. Terrorist attacks often

entail the use of organic, homemade explosives. These are relatively straightforward to make and the necessary raw materials are generally easy to acquire. The highly explosive material TATP is commonly used in terrorist attacks, including the attacks on the Stade de France in Paris (2015) and the Manchester Arena (2017). ETN, an organic nitrate ester, is increasingly being used as well. Bezemer made a large number of batches of both explosives. To be clear: she made them in safe conditions and in small quantities under varying synthesis conditions, each time using different processes, under varying conditions and with different raw materials. "This enables us to compile databases that we can use for the chemical profiling of organic explosives, which are badly needed. In comparison, for drug-related forensic research, a vast number of databases are readily available, containing information on the chemical composition and production processes. These databases can be created because of the ample availability of drug samples from ongoing investigations. For explosives, this situation is of course quite different, which means that you have to create your own samples in order to obtain such information."

Flash bangers

"Organic explosives account for only part of the casework in the Netherlands. Most cases involve firework misuse," says Bezemer. "This poses a serious safety risk, and not just because of irresponsible, risky behavior by the people involved, usually young adolescents. Criminals also use heavy fireworks, so-called 'flash bangers,' for example for extortion, assaults, or attacks on ATMs. In addition to the illegal use of legally produced fireworks, there is also the issue of cheaper imitation flash bangers, particularly with the Cobra. These look virtually identical to real Cobras, but are a lot less reliable and therefore much more dangerous as well. They often contain cheap filler material, such as gravel or sawdust, and the fuses are usually substandard."

Bezemer developed methods to distinguish between different batches of Cobras and imitation Cobras. To this end, she created a large collection of batches of Cobra fireworks in collaboration with the police. This enables to distinguish different types of seized batches of fireworks from each other. This can assist the police in their fight against the illegal trade in, and the misuse of, Cobras for criminal and terrorist activities. In the case of post-explosion investigative work, most of the external features of a flash banger have been destroyed and the residues found rarely allow the firework's characteristic properties to be determined. Bezemer devised a method which still makes it possible to distinguish between different batches of fireworks based on the trace elements in the plastic caps, which are almost always found partially or even completely intact.

Trace detection

Firework legislation differs from country to country, but even in countries with strict regulations like the Netherlands heavy fireworks are relatively easy to obtain on the black market, for example using the internet. This makes it possible for criminals and terrorists to make powerful explosives in relative anonymity and with fewer safety risks than if they were to produce an organic explosive at home. Consequently, police and investigation services are increasingly focusing on the illegal production of fireworks and their distribution (whether legal or illegal). Bezemer investigated two screening techniques for the detection of firework traces on packaging materials. The initial findings she identified could help in the future with the large-scale screening of mailed parcels, aimed at detecting the illegal distribution of fireworks.

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